Intersection Syndrome in a Handcyclist: Case Report and Literature Review

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Intersection syndrome describes a rare inflammatory condition located at the crossing point between the first dorsal compartment muscles and the radial wrist extensor muscles. It is a repetitive motion injury that affects patients who overuse their wrists. The present report reviews the incidence of the condition as well as the special populations it affects. The anatomy of the wrist is presented and clinical findings and physical examination techniques are reviewed to help the reader reach a quick but correct diagnosis. Finally, the most appropriate treatment approach is presented, incorporating rehabilitative methods designed to ensure a full and prompt functional recovery and resumption of physical activity. **Key words:** *handcycling, intersection syndrome, peritenosynovitis, spinal cord injury*

Clinical Presentation

A 35-year-old, right-hand-dominant male with a complete spinal cord injury at the level of the 7th thoracic vertebra (T7 AIS A) presented to the clinic with severe pain, erythema, and swelling on the lateral aspect of the left forearm 2.5 inches proximal to the snuff box (**Figure 1**). The pain was exacerbated with any movement of the wrist, but especially so with wrist extension. Finger flexion and extension were also pain triggers, albeit to a lesser degree. The pain was somewhat relieved with application of ice. There was localized erythema and tenderness to palpation over the site of swelling. Sensation was intact to pinprick and light touch in all upper limb dermatomes, and mild weakness in the left wrist and fingers was attributable to pain. There was no crepitus to palpation, and Finkelstein's and Eichoff's tests were negative. The radial pulse was strong. The patient, who had a past medical history significant for paraplegia as a result of a snowboarding accident that occurred 4 years previously, gave a history of using a mountain handcycle to climb 3,000 feet from the base of a ski resort to its highest peak at 11,000 feet of elevation. To accomplish this, he pedaled continuously for 7 hours. He had been training for 2 months to accomplish this feat; the training sessions consisted of using the bike to climb around the base of the resort for 90 to 120 minutes at a time once weekly. The climb was the first time he rode the bike for more than 2 hours. He states that the pain came on abruptly after approximately 5 hours of pedaling. The pain was described as a sharp stabbing sensation with each pedal rotation and was so severe in intensity that he thought he had sustained a stress fracture in his radius. He continued the climb to the summit in spite of the pain to reach his goal. Upon taking the tram down after completing the climb, he found it difficult to use his left arm to perform the transfer back to his wheelchair. Within 2 hours, it was difficult for him to propel his manual wheelchair. Ultrasonographic exploration of the radial forearm at the time of the clinic visit, 3 days post injury, demonstrated the presence of a fluid collection around the tendon sheaths of the extensor pollicis brevis (EPB) and abductor pollicis longus (APL) at the level of their intersection with the extensor carpi radialis brevis (ECRB) and extensor carpi radialis longus (ECRL) (**Figure 2**). A clinical diagnosis of intersection syndrome was made, and the patient was prescribed a cock-up wrist splint with 20° of dorsal angulation (Procare Quick-Fit Wrist II; DJO Global, Vista, CA) to be worn for 2 weeks. Naproxen 500 mg orally twice daily was prescribed to decrease the inflammatory response. At 1-week follow-up, the patient stated that he had developed significant crepitus over the area, especially with thumb abduction 3 days after the initial visit, but

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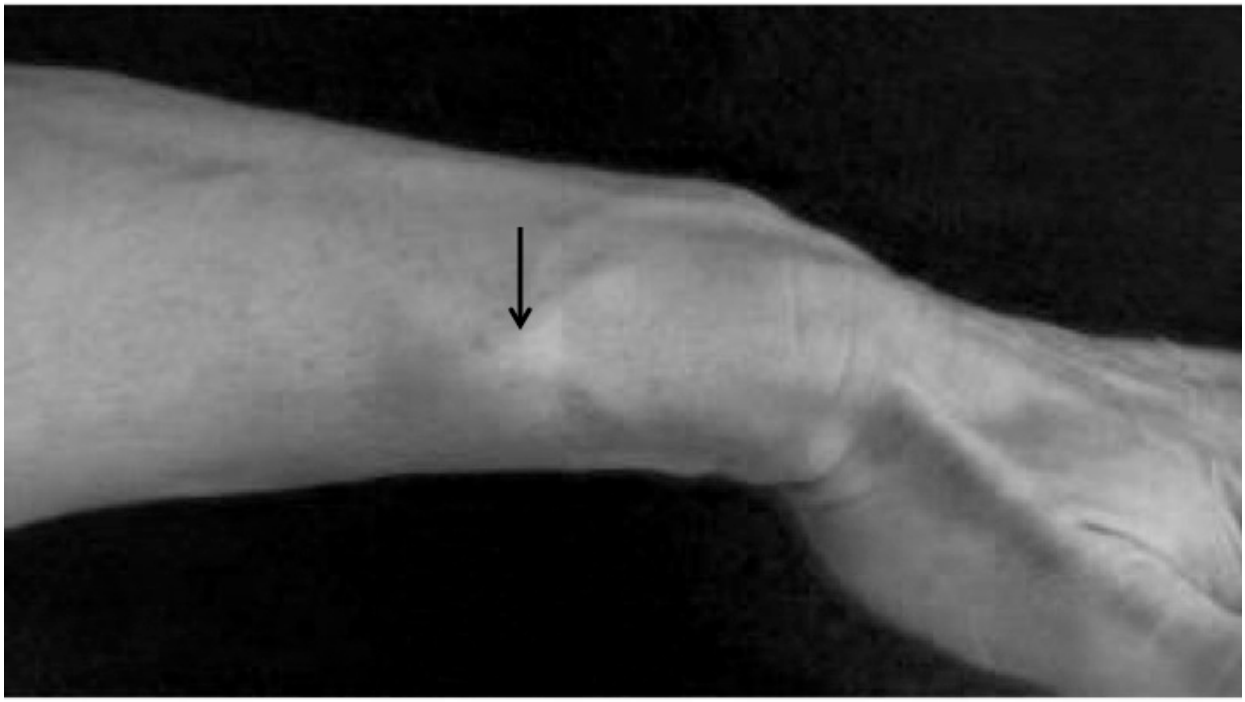

Figure 1. Surface anatomy of the intersection of the first and second extensor compartments.

that the pain had responded well and quickly to the naproxen. Repeat ultrasound showed residual fluid collection without much improvement. The naproxen prescription was switched to as-needed for pain. At 2-weeks follow-up, the patient had neither crepitus nor pain with motion of the wrist or digits, even without the use of naproxen. The use of the wrist splint was discontinued. Repeat ultrasound revealed complete resolution of the peritendinous fluid collection. The patient trained with a stationary handcycle with vertical handles not necessitating flexion and extension wrist motion during pedal rotation and had no recurrence of symptoms at the 2-month follow-up. He resumed actual road handcycling with vertically oriented handles; he completed a marathon 5 months after the injury and completed 10 marathons within a year of the injury. Resumption of handcycling with the off-road bike that did not have vertical handles was resumed 8 months following the injury without the use of a wrist brace in sessions not exceeding 2 hours. None of these activities led to recurrence of symptoms.

Discussion

Definition of intersection syndrome

Repetitive motion injuries are seen in any practice dealing with musculoskeletal disorders. These injuries have been known as cumulative trauma disorder, overuse syndrome, repetitive stress injury, and repetition strain injury.[1] In British Commonwealth countries, the most common term is repetitive stress injury (RSI), whereas in the United States, cumulative trauma disorder (CTD) is the preferred label.[1-3] These disorders include a variety of clinical entities, such a tenosynovitis, tendinitis, enthesopathies, and compressive neuropathies.[1] Intersection syndrome is acquired through repetitive strain. Tenosynovitis appears to have been first observed by Velpeau in 1818 and was later described by him in his Anatomie Chirurgicale published in 1825. Another Frenchman, Boyer, noted that the lesion lay outside the tendon sheath proper and named it cellulite peritendineuse. Troell confirmed these observations in 1918 and suggested the

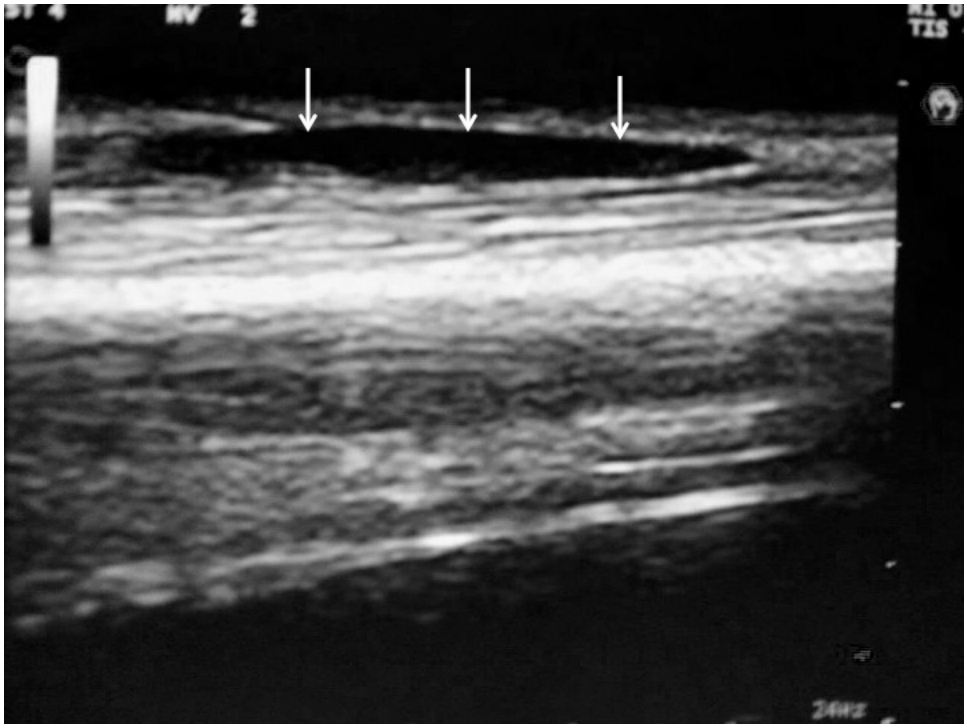

Figure 2. Evidence of fluid collection by ultrasound over the tendon sheaths of the extensor pollicis brevis (EPB) and abductor pollicis longus (APL) at the level of their intersection with the extensor carpi radialis brevis (ECRB) and extensor carpi radialis longus (ECRL).

name peritendinitis crepitans.[4] Dobyns et al introduced the term intersection syndrome.[5] Intersection syndrome is a relatively uncommon overuse syndrome that is associated with an inflammatory condition or peritenosynovitis at the intersection of the radial wrist extensors and the APL and EPB.[1,5] This injury usually results from repetitive wrist flexion and extension against resistance.[6] This specific condition is known also as peritendinitis crepitans, bugaboo forearm, abductor pollicis longus bursitis, crossover syndrome, oarsman's wrist, adventitial bursitis, subcutaneous perimyositis, or squeaker's wrist in the literature.[5,7] Simply put, intersection syndrome describes an inflammatory condition located at the crossing point of the first dorsal compartment muscles (APL and EPB) and the radial wrist extensors (ECRL and ECRB).[8]

Incidence

At one factory employing 12,000 people, medical records revealed that about 40 cases of tenosynovitis occurred annually, which represents a 0.33% incidence.[4] In a study looking at 8,000 patients who presented with arm or hand pain in Thailand, the prevalence of intersection syndrome was found to be 0.37%.[7] In the general population, the prevalence varies between 0.20% and 0.37% depending on the studies.[5] Although the incidence of intersection syndrome has not been studied among athletes, it is known that in general up to 50% of all sports participants will be injured and that 25% to 50% of these injuries will be attributed to overuse. These types of injuries commonly involve the upper extremity, and the wrist is the most frequently affected site.[8] One study by Palmer, looking at wrist injuries related to helicopter skiing in the Bugaboo mountains of British Columbia, suggested an incidence of intersection syndrome of 21% in that population of skiers.[9]

Populations most affected

Intersection syndrome is commonly diagnosed in workers or athletes whose activities involve

repetitive wrist flexion and extension[7,9,10] as well as repetitive, high compressive forces at the wrist.[7] Out of 370 amateur tennis players screened with a questionnaire appropriately prepared to investigate wrist injuries, 320 players reported no injuries in their activity and 50 reported injuries to the wrist, of which only 1 was found to have suffered from intersection syndrome on review of the medical record, representing a 2% incidence.[11] Hanlon described a patient with intersection syndrome who had performed 10 hours of landscaping 1 day before the onset of symptoms.[12] It has also been reported in rowers[6,11,13] as well as gymnasts[12] and can be seen in racquet, stick, and club sports including badminton, baseball, cycling, field hockey, golf, ice hockey, racquetball, skiing, softball, squash, and tennis.[6] The condition has not been reported in handcyclists in the literature. From this presented case, it would appear that within the handcycling community, those most at risk use horizontally oriented handles necessitating wrist flexion and extension for extended periods of time.

Etiology

Zollinger in 1927 studied 929 cases reported to a Swiss insurance company and stressed the importance of persistent strain rather than trauma as a cause for intersection syndrome.[14] Reed and Harcourt in 1943 described 70 cases, 40 of which were from strains, 13 from contusions, and 13 from repetitive movements.[15]

Differential diagnoses

The differential diagnoses for intersection syndrome include De Quervain's tenosynovitis, a tenosynovitis of the extensor tendons in the first dorsal compartment of the wrist, and tenosynovitis of the second or third dorsal compartment. Other differential diagnoses include blunt local trauma, or Wartenbeg's syndrome, an entrapment of the dorsal radial sensory nerve as it emerges beneath the brachioradialis.[7,10]

Anatomical review

Wrist extensor muscles are organized in 6 compartments over the dorsal aspect of the wrist (**Figure 3**). Most lateral on the dorsal wrist is the first extensor compartment that contains the tendons of the APL and the EPB muscles. Medial to it is the second extensor compartment that contains the tendons of the ECRL and ECRB. On the ulnar side of the dorsal radial tubercle is the third compartment that contains the tendon of the extensor pollicis longus muscle. Adjacent to it is the fourth compartment containing the tendon sheath for the extensor digitorum and the extensor indicis muscles. Ulnar to it is the fifth extensor compartment that contains the extensor digiti minimi. Finally, the sixth compartment is the most dorsal medial and contains the tendon of the extensor carpi ulnaris. In total, there are 6 synovial tendon sheaths occupying 6 osseo-fibrous tunnels giving passage to 9 tendons. The extensor tendons are held in place by the extensor retinaculum, preventing bowstringing of the tendons when the hand is extended at the wrist. It is important to note that the first and second extensor compartments intersect each other 2 inches proximal to Lister tubercle (**Figure 1**).

Physical examination

A detailed history alone may lead to a specific diagnosis in approximately 70% of wrist pain cases.[8] Physical examination should include a thorough neurologic and cardiovascular examination including peripheral pulses and a comprehensive examination of the neck and upper extremities to rule out radiating pain from a more proximal problem such as a herniated cervical disc. The hand and the wrist can be palpated to localize tenderness to a specific anatomical structure. Evaluation of the wrist should begin with identifying erythema, swelling, masses, skin lesion, muscle atrophy, contractures, scars, or other obvious deformities. The injured wrist's active and passive range of motion should be evaluated and compared with the contralateral wrist. Wrist flexion (average maximum, 70°), extension (70°), ulnar deviation (40°), and radial deviation (20°) are evaluated, as well as forearm supination (80°) and pronation (80°).[16] The clinician must characterize the precise nature of the pain, including its quality, radiation, severity, and timing, as well as palliative and aggravating factors. In addition, the patient

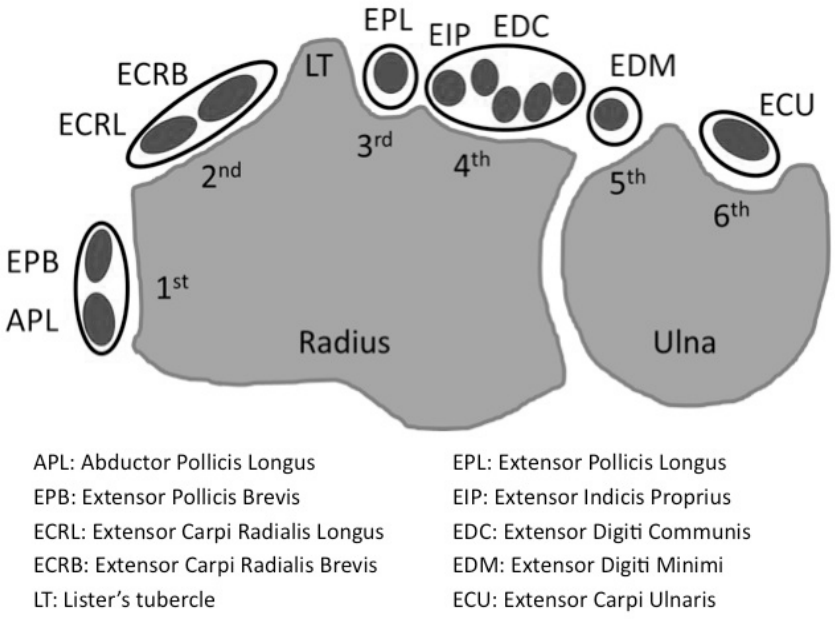

Figure 3. Cross-section of the 6 extensor compartments of the wrist.

should point with one finger to the most painful area and indicate where the pain radiates.[16]

Clinical findings

Pain and swelling are usually noted 2 inches proximal to the radial carpal joint on the dorsal surface of the forearm.[8] Of the 30 patients with intersection syndrome evaluated by Pantukosit, all of them had forearm pain, 22 had swelling, 12 had crepitus, and 14 had pain with twisting hand motion.[7] One case report described swelling and tenderness 2 inches proximal to the radial styloid, significant crepitus but no overlying erythema, minimal warmth, and a positive Finkelstein's test for pain elicited in the area of tenderness.[12] It is important to note that on physical examination, pain in the radial styloid region with abrupt passive medial deviation of the thumb, while thought to be a pathognomonic sign of De Quervain's tenosynovitis, can still be positive in patients with basal thumb-joint arthrosis and in intersection syndrome.[7,17]

Imaging

Clinical examination is usually sufficient for an accurate diagnosis, but ultrasound or magnetic resonance imaging can be helpful in doubtful cases.[11] Other imaging can include technetium bone scan and computed tomography.[16] If plain films are indicated to rule out bony pathologies, it is essential to obtain posterior-anterior and lateral views.[17] Ultrasonography is a quick and accessible way to assess soft-tissue abnormalities such as tendon injury, synovial thickening, ganglia, and synovial cysts, but it is important to note that its effectiveness is highly operator-dependent.[16]

Treatment

Proper treatment should always start with patient education.[1] An understanding of what caused the problem is essential to prevent its future occurrence. Howard described 2 series of 32 and 72 cases, respectively, and stressed the importance of absolute immobilization with a splint that should include the thumb.[18,19] Well-immobilized

patients would heal in 11.6 days, whereas poorly immobilized patients would have an average disability period of 45.7 days. Pozner suggested a treatment of strapping or use of a cock-up wire splint with absolute rest for 3 weeks.[20] Treatment with a plaster immobilization combined with passive movements every other day and short-wave diathermy was the recommended treatment in 1943.[4] Current management of intersection syndrome is similar to the management of most overuse syndromes, and the first-line therapies include rest, nonsteroidal anti-inflammatory drugs (NSAIDs), and an immobilizing splint.[12] Even though the inflammatory response is essential to the healing process, limitation of its intensity and duration is the goal of early treatment. Ice, elevation, NSAIDs, and compression will not only limit inflammation but can also decrease the associated pain. Rest seems to remain the most important treatment modality; most cases will resolve with splinting in 20° of extension for 2 to 3 weeks.[8,12] All 30 patients seen by Pantukosit received an analgesic and NSAIDs and were advised to modify hand activity. Only 1 patient received a hand splint in addition to the other treatments. At the 1-week follow-up visit, all the patients reported favorable responses to these approaches.[7] Corticosteroid injections are frequently included as treatment options in clinical guidelines in the field of musculoskeletal disorders.[21] It is necessary to understand and share with the patient the list of possible adverse events, which can span from simple ecchymosis to tendon rupture. Overall, the incidence of major adverse events can be up to 5.8% in the patients treated.[21] Injection therapy with an anesthetic–steroid combination (2 mL of 1% lidocaine with betamethasone) is generally reserved for cases that do not resolve with 2 or 3 weeks of splinting. In patients refractory to first-line management with NSAIDs and immobilization, steroid injections to the area of maximal tenderness can be used as second-line treatment and have been found to result in the resolution of symptoms within 10 days.[12] Surgical intervention, while very effective and curative in virtually all cases,[22] is only offered to patients who do not respond to more conservative management[23,24] and consequently has a limited role.[1]

Rehabilitation

At the completion of the healing process, the musculotendinous unit can be rehabilitated to its preinjury strength and trained to handle the loads imposed by the sport or the activities of daily living. Usually, a course of 4 to 6 weeks of progressive stretching and mobilization will achieve this goal. Most patients will do fine without any specific therapy, but athletes may benefit from it in order to optimize their healing. The 10% rule (increase the weight, repetitions, or distance by 10% per week) has been used with good success in runners and is recommended as an excellent starting point for upper extremity rehabilitation.[8] In the case of our patient, he maintained his cardiac fitness and arm endurance with a stationary handcycle with vertical handles not necessitating wrist flexion or extension during pedal rotation. When resuming activity with the off-road bike with horizontal handles, he limited the duration of his training sessions.

Controversies

There is some disagreement regarding the true etiology of intersection syndrome; most describe it as peritenosynovitis,[22,25,26] whereas others use the term tendinosis.[27] Peritenosynovitis implies an inflammatory process around the tendon sheaths; this concept is supported in intersection syndrome by the resolution of the symptoms in the majority of cases with the use of anti-inflammatory therapies, such as oral NSAIDs[7] or peritendinous corticosteroid injections.[12] Tendinosis implies chronic tendon degeneration without inflammation. Given the acute onset of intersection syndrome that can, in most cases, be clearly linked to an episode of overuse, tendinosis, by definition, seems unlikely. In addition, several authors localized the pathology of intersection syndrome outside the tendon sheaths and not within the tendons themselves,[4,22] further supporting the concept of peritenosynovitis.

Disagreement also exists regarding the precise site of the peritenosynovitis. Some believe that the peritenosynovitis in intersection syndrome is localized to the intersection between the first and second extensor compartments,[8] and

others believe that it is a peritenosynovitis of the second extensor compartment only.[22] A positive Finkelstein's test in some patients with intersection syndrome indicates that there is involvement of the first extensor compartment in addition to involvement of the second compartment.[7,12,17] The precise location for the tenosynovitis will influence the choice of the most appropriate splint. Our patient used a cock-up splint, which fully immobilized the wrist and only minimally immobilized the thumb; he developed significant crepitus at the level of intersection of ECRL/ECRB and APL/EPB tendons with thumb abduction despite proper use of the splint. The ECRL and ECRB tendons could be successfully immobilized with a cock-up splint with 20° of dorsiflexion, but a thumb spica splint would additionally immobilize the APL and EPB tendons.[28] The outcome seen in our patient indicates that immobilizing only the ECRL and ECRB was suboptimal and that both the first and second compartments are involved in intersection syndrome and should be immobilized, as recommended by Howard.[18,19] In retrospect, the use of a thumb spica splint might have been more adequate to immobilize all 4 tendons.

Conclusions

Intersection syndrome is a peritenosynovitis that can affect a variety of athletes. It is important to note that as persons with SCI become more active, they also become susceptible to injuries from cumulative trauma. In this population that relies heavily upon upper extremity use, it is important to correctly diagnose this pathology to provide the most appropriate treatment approach and facilitate a prompt but safe return to activity.

Acknowledgments

The author reports no conflicts of interest.

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